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(54) Forming double-layer hollow film

(57) A molten thermoplastic resin is extruded in the form of a double-layer cylindrical hollow film (4) in which the two film layers are interconnected with each other by a number of spaced legs, and then immediately passed through an annular gap defined by the outer and inner side walls of an inner and outer vessel (2, 3), respectively, in such a manner that the two film layers are in contact with the side walls defining the gap. Liquid coolant is supplied to the inner and outer vessels so as to overflow the side walls and bring the coolant into contact with the resin, the overflow level of the coolant above the both side walls being adjusted so as to be equal to each other and also to exert a liquid pressure on the extruded resin which balances the pressure of a gas supplied between the two film layers and said legs of the extruded resin.

FIG. 1

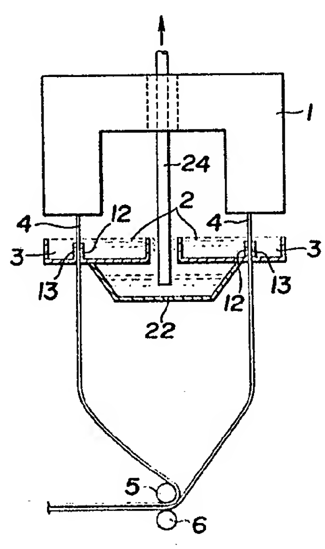
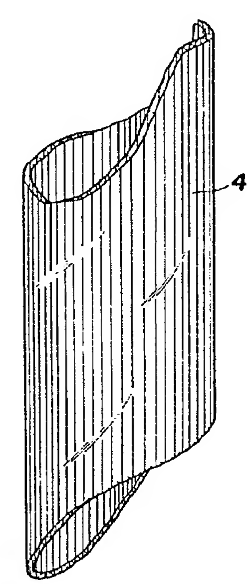


FIG. 4



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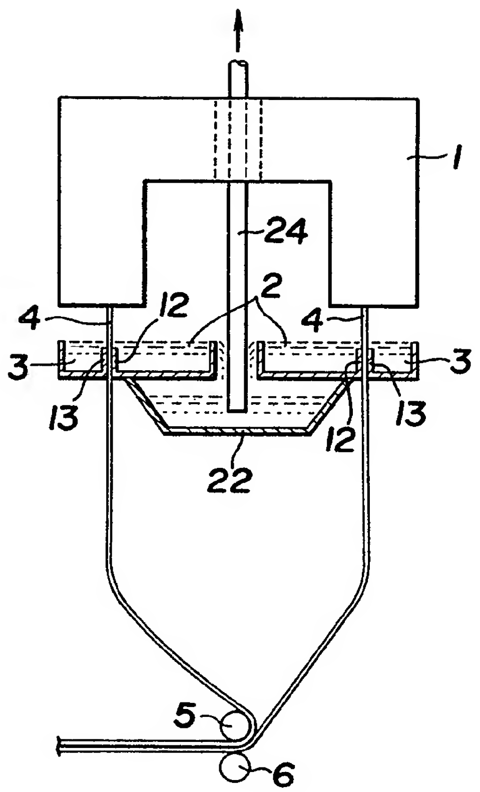
F I G. 1



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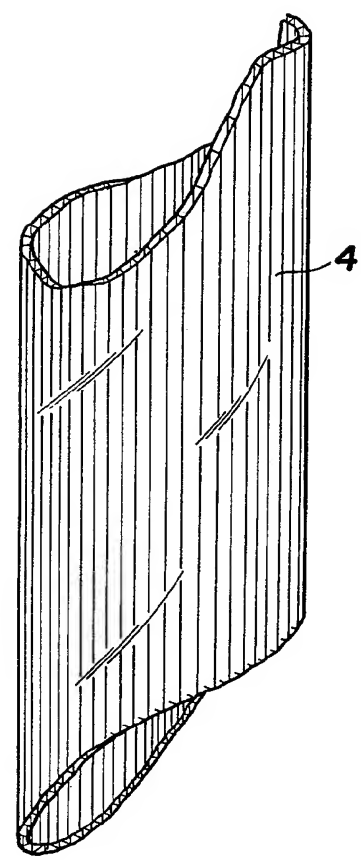


F I G. 2

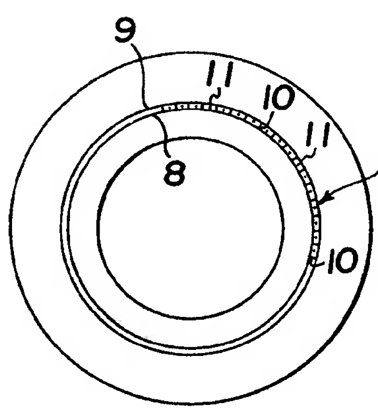
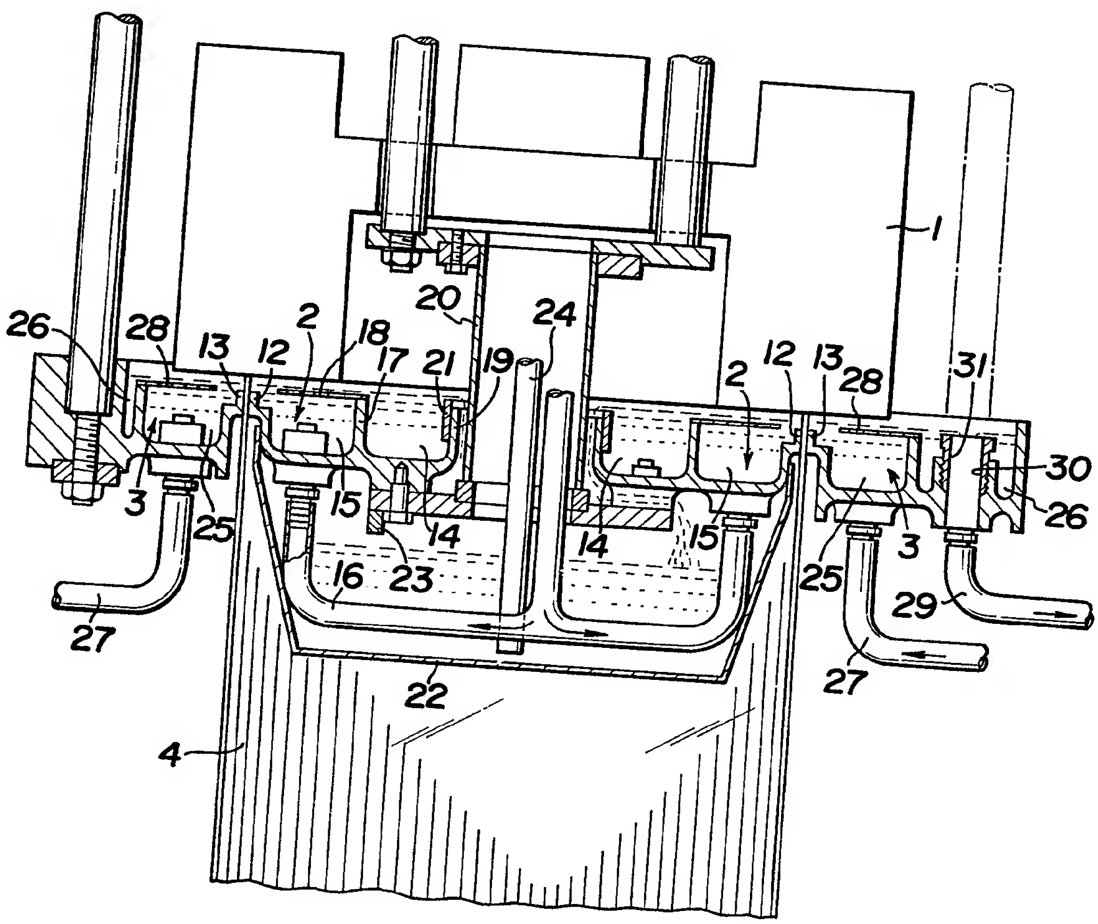


FIG. 3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SPECIFICATION

Method and apparatus for forming double layer hollow film

The present invention relates to a method and apparatus for forming a double-layer hollow film, in which a pair of film layers are interconnected integrally by a number of spaced legs so as to define a number of elongate compartments between the pair of film layers.

A hollow film of the kind referred to has an excellent heat insulative property, i.e. heat-storing property, over the conventional mono-layer sheet film and therefore it has recently drawn much attention as a converting material for greenhouses. However, if such a hollow film shows a much lower light permeability as compared with the known mono-layer sheet film because of its double-layer hollow construction, sufficient solar heat produced in the day time cannot be stored within the greenhouse. Further, if the legs bridging the pair of films cannot separate these films sufficiently to define elongate compartments therebetween, the heat insulation effect is decreased so as to be too low for use as a covering material for greenhouses. In addition, it is required that such hollow films can be wound up for storage and transportation as in the case of the convenitional mono-layer sheet film. It is also necessary for the hollow film to have sufficient flexibility so as to increase working efficiency.

With known technique, however, it has been impossible to economically form a double-layer hollow film in which a pair of film layers are integrally moulded with a plurality of legs by a thin, flexible and transparent resin for obtaining a desired level of light permeability, and further in which the legs are thin but firm enough to prevent the compartments between the pair of film layers defined thereby from being deformed or crushed.

In one method for forming a double-layer hollow film, an inflation extrusion process has been proposed as disclosed in Japanese Patent Laid Open Application No. 133263/1975. According to this inflation extrusion process, a molten thermoplastic resin is inflated as it is extruded from an annular extruding die comprising a pair of annular slits, having different diameters and arranged concentrically, and a plurality of slits interconnecting these annular slits. Upon inflating this extruded resin, in order to prevent the legs interconnecting the film layers being irregularly deformed or bent, it becomes necessary to regulate the pressure of gas supplied to the central cavity of the annularly inflated film and also the pressure of gas supplied between the smaller and larger diameter slits. However, such a regulation is extremely difficult to carry out with today's techniques. Further, in the known process, the inflated resin is subjected to air-cooling for curing. However, the air-cooling takes a long time, during which resin is generally likely to extend becoming thinner so that the legs between the film layers are distorted or bent. The light permeability of the resin is also decreased during the slow cooling, resulting in a low utility.

A water-cooling process can be employed instead of the air-cooling. The known water-cooling process, however, which has been used for cooling mono-layer film, cannot provide a simultaneous and uniform cooling to the two film layers providing deformation of the compartments defined therebetween. Thus, water-cooling has defects similar to those of air-cooling.

It is therefore an object of the present invention to improve the above-mentioned known method and apparatus for forming a double-layer hollow film.

Another object of the present invention is to provide a method and apparatus for forming a double-layer hollow film high light permeability and desired thickness as well as flexibility.

A further object of the present invention is to provide a method and apparatus as set forth above, in which the double film layers are separated as desired by legs located therebetween, for enchancing heat insulation.

According to the present invention, there is provided a method for forming a double-layer hollow film comprising the steps of: extruding molten thermoplastic resin in the form of a double-layer cylindrical hollow film comprising two film layers interconnected with each other by a number of spaced legs, and immediately passing the extruded resin through an annular gap defined by respective outer and inner side walls of an inner and an outer vessel in such a manner that the two film layers are in contact with said respective side walls defining said gap, wherein liquid coolant supplied to said inner and outer vessels is caused to overflow said side walls to bring said coolant into contact with said resin, the overflow level of said coolant above both side walls being adjusted equal each other and also to have a liquid pressure on the extruded resin which balances the pressure exerted by a gas supplied between said two film layers and said legs of the extruded resin.

According to another aspect of the present invention, an apparatus for forming a double-layer hollow film is provided which comprises an extruding die, the outlet of which has a pair of concentric inner and outer annular slits provided closely adjacent each other and a number of leg slits extending between the pair of annular slits. The extruding die also has means for feeding a pressurized gas between the pair of annular slits and the leg slits in the outlet. Provided below the extruding die are inner and outer vessels, the inner vessel being located at the inner position of the pair of annular slits and the outer vessel is located around the inner vessel. The inner and outer vessels have an outer annular side wall an an inner annular side wall, respectively, which define an annular gap therebetween through which the resin extruded from the outlet of the extruding die in the double-layer cylindrical form passes in contact with the inner and outer annular side walls. The apparatus further comprises means for supplying liquid coolant to the inner and outer vessels to overflow therefrom and means for adjusting the

overflow level of the coolant above the upper end surfaces of the outer and inner side walls of the inner and outer vessels, respectively, to equal each other. The overflow level of the coolant is adjusted to exert a liquid pressure on the extruded resin which balances the pressure exerted by the gas supplied between the pair of annular slits and the leg slits.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a partially sectioned schematic front view of an apparatus according to an embodiment of the present invention;

Figure 2 is a partially sectioned plan view of an outlet of an extruding die of the apparatus shown in Figure 1;

Figure 3 is a partially sectioned front view of a cooling device used in the apparatus shown in Figure 1, and

Figure 4 is a perspective view of a portion of a double-layer cylindrical hollow film formed by means of the process of the present invention.

The apparatus shown in Figure 1 comprises a die 1 for extruding a molten thermoplastic resin, immediately below which there are provided an inner annular coolant vessel 2 and an outer annular coolant vessel 3. The thermoplastic resin 4 extruded from the outlet of the extruding die 1 in a double-layer cylindrical form is cooled and cured immediately by a liquid coolant, e.g. water, in these two coolant vessels 2 and 3 and then folded by a pair of pinch rollers 5 and 6 from the cylindrical form into a sheet form. The thus folded film is severed at one side and wound up in a proper fashion as double-layer hollow sheet film.

The outlet 7 of the extruding die 1 comprises as shown in detail in Figure 2, a pair of annular slits 8 and 9 provided concentrically and closely adjacent to each other and a number of leg slits 10 extending between the annular slits 8 and 9. These annular slits 8 and 9 and two adjacent leg slits 10—10 define unit compartments, each of which includes an air blast hole 11. With this construction of the outlet 7, the molten thermoplastic resin 4 extruded from the extruding die 1 forms a double-layer cylinder having two layers interconnected by a number of legs. In this embodiment, since the air supplied from the air blast holes 11 does not have such a pressure as to inflate the resin forming the two layers, the molten thermoplastic resin is introducted into the coolant vessels 2 and 3 having substantially the form of the initial double-layer cylinder.

The coolant vessels 2 and 3 are arranged just below the outlet 7 of the die as shown in detail in Figure 3.

In this embodiment the space between the outlet 7 and the water level in the coolant vessels should be as small as possible, preferably, about 10 mm to 20 mm so that the double-layer resin is subjected to water-cooling immediately after extruded from the die 1. The outer vertical wall 12 of the inner annular coolant vessel 2 is slightly spaced from the inner vertical wall 13 of the outer annular coolant vessel 3. The diameters of the outer and inner vertical walls 12 and 13 of the inner and outer vessels 2 and 3 are almost equal to those of the inner and outer annular slits 8 and 9 in the outlet of the extruding die 1, respectively. But, the gap formed between the vertical walls 12 and 13 is a little narrower than that between the concentrically arranged annular slits 8 and 9. The double-layer film, drawn by the pinch rollers 5 and 6 so as to decrease the space between the film layers, is guided vertically between the outer and inner vertical walls 12 and 13 with the film layers in contact therewith.

The inner annular coolant vessel 2 has an inner annular recess 14 and an outer annular recess 15 separated by a partition wall 17. A water supply pipe 16 is connected to the outer annular recess 15 in the bottom, through which cooling water is supplied to the recess 15. At the upper end of the partition wall 17 a deflection plate 18 is provided for guiding the cooling water supplied to the recess 15 towards the upper portion of the outer side wall 12 of the recess 15. The inner side wall 19 of the inner annular recess 14 defines a central opening of the coolant vessel 2, through which a large diameter pipe 20 supporting the coolant vessel 2 extends, spaced from the inner side wall 19. Screwed on to the inner side wall 19 is a water level regulator ring 21. With such a construction, the cooling water supplied from the pipe 16 into the outer annular recess 15 overflows towards the upper portion of the outer vertical side wall 12 and bears against the inner film layer of the double-layer cylindrical film for cooling and curing this layer, and then flows over the upper surface of the deflection plate 18 into the inner annular recess 14. The water, surpassing the upper end of the water level regulator ring 21, flows down through the gap between the inner side wall 19 and pipe 20 and is stored temporarily in a water reservoir 22 provided below the inner coolant vessel 2. The vessel of the water stored in the reservoir 22 is detected by a detector 23 and when the detector 23 detects a water level higher than a predetermined value, water is exhausted to the outside through a drain pipe 24 which extends through the large diameter pipe 20. As can be understood from the foregoing description, the regulation of the water level above the outer vertical side wall 12 for cooling the extruded film, can be achieved by vertical displacement of the water level regulator ring 21.

The outer annular coolant vessel 3 is also divided into an inner annular recess 25 and an outer annular recess 26. A water supply pipe 27 is connected to the bottom of the inner annular recess 25, through which cooling water is supplied to the recess 25. A deflection plate 28 is provided at the upper end of a partition wall between the annular recesses 25 and 26 for guiding the cooling water supplied into the recess 25 toward the upper portion of the inner vertical side wall 13. A drain pipe 29 is connected to the outer annular recess 26 through the bottom thereof and provided with a water outlet 30 on

which a hollow cylindrical nut 31 is screwed in the vertical direction for regulating the water level. With such a construction, the cooling water supplied from the pipe 27 into the inner annular recess 25 overflows in a direction towards the upper portion of the inner vertical side wall 13 to bear against the outer film layer of the double-layer cylindrical film for cooling and curing this layer, and then flows over the upper surface of the deflection plate 28 into the outer annular recess 26. The water, surpassing the upper end of the water level regulator nut 31, is exhausted to the outside through the drain pipe 29. As can be understood from the foregoing description, the regulation of the level of the water which bears against the extruded film can be carried out by changing the height of the water level regulator nut 31.

Thus, in accordance with the present invention, inner and outer annular coolant vessels 2 and 3 are provided for cooling the resin, extruded in a double-layer cylindrical form. In addition, the inner vessel is provided with a water level regulator ring 21 and the outer vessel a water level regulator nut 31 which is hollow and cylindrical. The cooling water is regulated by the ring 21 and nut 31 to be at the same level with respect to the inner and outer film layers. Further, in order to prevent inward distortions of the film layers and bending of the legs between the film layers, the air fed through the air blast hole 11 provided between the annular slits of the die is kept at the same pressure level as that of the cooling water bearing against the film layers. Some experimental embodiments of the present invention is described in the following examples:

EXAMPLE 1

Ethylene vinyl acetate resin of MI (Melt Index) 2 containing 15% of vinyl acetate and molten at the temperature of 190°C was extruded in a double-layer cylindrical form from the outlet 7 of a die 1 as shown in Figure 2 by means of a 90 mm extruder at the rate of 100kg/h. The inside wall defining the inner annular slit 8 and the outside wall defining the outer annular slit 9 were spaced from each other by 6.2 mm in the outlet and the leg slits were mutually spaced by 4.0 mm. The resin extruded in the double cylindrical form was immediately led into cooling water and guided between the outer side wall 12 of the inner annular coolant vessel 2 and the inner side wall 13 of the outer annular coolant vessel 3. The space between the upper end of the side walls 12 and 13 and the die outlet 7 was about 20 mm. While the air fed through the air blast hole 11 between the annular slits 8 and 9 of the die was set at a water column pressure of about 25 mm, the water level above the upper end of the inner and outer side walls 12 and 13 was varied. When the water level, which was increased gradually, exceeded a height of 20 mm above the upper end of the side walls 12 and 13, the film layers began to be distorted toward each other, some legs bent, and the cooling water dropping through the space formed between the side walls 12 and 13 and the film layers due to the inward distortion of the film layers. To the contrary, when the water level, which was decreased gradually, became lower than 5 mm, the film began to inflate due to the air pressure supplied between the film layers and the cooling efficiency became too low to secure a stable quality of film. When the water level was set at the height of 15 mm in view of the above results, the inner and outer film layers were properly kept in contact with the inner and outer side walls 12 and 13 so as to prevent cooling water from flowing down therebetween. The air pressure was balanced with the hydraulic pressure across the film layer so as to prevent inward or outward distortion of the film layers and bending of the legs. The cooling water seemed as if it were stationary with the surface thereof appearing like a mirror. Under these stable cooling conditions, the double-layer cylindrical film was cooled and cured at a rate of 5m/min. The film having passed through the coolant vessels 2 and 3 was folded by a pair of pinch rollers into a sheet form. One side of the film was cut open by means of a cutter knife into a wide sheet having a width of 2 to 3m and then taken up by a conventional winder.

The resulting double-layer film had a so-called observed thickness of 2.0 mm between the film layers and a unit weight of about 150 g/m^2. The general light permeability was as high as about 85%. The film was very flexible there being no leg bending present.

EXAMPLE 2

High pressure polyethylene of MI 2 of the type used for forming heavy duty bags was extruded from the outlet of the die substantially in the same manner as in Embodiment 1. While the air pressure fed between the film layers was set at a water column pressure of 30 mm, the water level was varied. When the water level was about 18 mm, the hydraulic pressure was balanced with the air pressure. Under the stable cooling conditions thus obtained, a polyethylene double-layer film could be produced.

EXAMPLE 3

Soft vinyl chloride resin molten at the temperature of 190°C was extruded from the outlet of a die in substantially the same manner as in the Embodiment 1. With the air pressure fed between the film layers was set at a water column pressure of 20 mm, the water level was varied. When the water level was about 10 mm, the hydraulic pressure was balanced with the air pressure. Under these stable cooling conditions a vinyl chloride double-layer film was produced.

CLAIMS

1. An apparatus for forming a double-layer hollow film, comprising an extruding die the outlet of which has a pair of concentric inner and outer annular slits provided closely adjacent each other and a number of leg slits extending between said pair of annular slits, said extruding die also having

means for feeding pressurized gas between said pair of annular slits and said leg slits in said outlet: an inner vessel provided below said extruding die and located at an inner position with respect to said pair of annular slits, an outer annular vessel provided below said extruding die and located around said inner vessel, said inner and outer vessels having an outer annular side wall and an inner annular side wall, respectively, which define an annular gap therebetween through which resin extruded from said outlet of said extruding die in the double-layer cylindrical form passes in contact with said inner and outer annular side walls, means for supplying liquid coolant to said inner and outer vessels to overflow said vessels, and means for adjusting the overflow level of said coolant above the upper end surfaces of said outer and inner side walls of said inner and outer vessels, respectively, to equal each other, the overflow level being adjustable to provide a liquid pressure on the extruded resin to balance the pressure exerted by the gas supplied between said pair of annular slits and said leg slits.

2. An apparatus as claimed in claim 1, wherein the diameter of said inner and outer annular slits in said outlet of the extruding die are substantially equal to those of said outer and inner side walls of said inner and outer vessels, respectively.

3. An apparatus as claimed in claim 1, wherein said inner and outer vessels are provided with deflection plates by means of which the coolant supplied to said vessels is deflected towards said outer and inner side walls of said inner and outer vessels, respectively.

4. An apparatus for forming a double-layer hollow film as described with reference to any one of Examples 1 to 3.

5. An apparatus for forming a double-layer hollow film substantially as herein described with reference to Figure 1 and 2 with or without reference to Figure 3 of the accompanying drawings.

6. A method for forming a double-layer hollow film comprising the steps of: extruding molten thermoplastic resin in the form of a double-layer cylindrical hollow film comprising two film layers interconnected with each other by a number of spaced legs, and immediately passing the extruded resin through an annular gap defined by respective outer and inner side walls of an inner and an outer vessel in such a manner that the two film layers are in contact with said respective side walls defining said gap, wherein liquid coolant supplied to said inner and outer vessels is caused to overflow said side walls to bring said coolant into contact with said resin, the overflow level of said coolant above both side walls being adjusted equal each other and also to have a liquid pressure on the extruded resin which balances the pressure exerted by a gas supplied between said two film layers and said legs of the extruded resin.

7. A method as claimed in claim 6, wherein the overflow level of said coolant above said side walls is in the range of from 5 to 20 mm.

8. A method as claimed in claim 6 or 7 with reference to any one of Examples 1 to 3.

9. A method for forming a double-layer hollow film substantially as herein described with reference to Figures 1 to 2 with or without reference to Figure 3 of the accompanying drawings.

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